at a lower temperature such as room temperature (about 25°C) or elsewhere in the range of about 0°C to less than about 100°C, whereas in another embodiment the gas mixture may at a higher temperature such as in the range of about 400°C to about 1000°C.

The invention is applicable to gas mixtures that may be at higher temperatures - gases for example in combustion streams such as automobile exhausts, diesel engines and home heating systems. The invention is also applicable, however, to gas mixtures derived from other sources, such as in manufacturing processes, waste streams, and environmental monitoring; or in systems in which odor detection is important and/or which are at lower temperature, such as in the medical, agricultural or food and beverage industries. The gas mixture may therefore have a temperature that is about 100°C or more, about 200°C or more, about 300°C or more, about 400°C or more, about 500°C or more, about 600°C or more, about 700°C or more, or about 800°C or more, and yet is less than about 1000°C, is less than about 900°C, is less than about 800°C, is less than about 700°C, is less than about 600°C, is less than about 500°C, is less than about 400°C, is less than about 300°C, is less than about 200°C, or is less than about 100°C.

This invention will further comprise means to determine, measure and record responses exhibited by each of the chemo/electro-active materials present upon exposure to the gas mixture. For example, any means that will determine, measure and record changes in electrical properties can be used. This may, for example, be a device that is capable of measuring the change in AC impedance of the materials in response to the concentration of adsorbed gas molecules at their surfaces. Other means for determining electrical properties can be suitable devices used to measure, for example, capacitance, voltage, current or DC resistance. Alternatively a change in temperature of

the sensing material may be measured and recorded. The chemical sensing method and apparatus may further comprise a means to measure or analyze the detected gases such that the presence of the gases are identified and their concentrations are measured. These means can include devices, such as instrumentation or equipment that is capable of performing chemometrics, neural networks or other pattern recognition techniques. The chemical sensor device will further comprise a housing for the array of chemo/electro-active materials, the means for detecting, and a means for analyzing.

The invention also provides a chemical sensor for directly sensing the presence and/or concentration of one or more gases in an multi-component gas system, said sensor comprising: a substrate, an array of at least two chemo/electro-active materials chosen to detect the predetermined gases in a multi-component gas stream, and a means to detect changes in electrical properties in each of the chemo/electro-active materials present upon exposure to the gas system. The array, gas of interest, gas stream, chemo/electro-active materials, and means for detecting are as described above.

The array of sensor materials should be able to detect an individual gas of interest despite competing reactions caused by the presence of the several other components of the multi-component mixture. For this purpose, this invention uses a an array of multiple sensor materials, as described herein, each of which has a different sensitivity for at least one of the gas components of the mixture to be detected. A sensors that has the needed sensitivity, that has the other attributes described herein, and that can operate in the types of conditions described herein, is obtained by selection of appropriate compositions of materials from which the sensor is made. Various suitable compositions of materials for this purpose are

described herein. The number of sensors in the array is typically greater than or equal to the number of individual gas components to be analyzed in the mixture.

The following non-limiting examples are meant to illustrate the invention but are not intended to limit it in any way. In the examples provided below, "chip" is used to describe an alumina substrate comprising an electrode and sensing material, and dielectric, if a dielectric is used. The notation "X% A:MO" means that another inorganic compound (A) has been added at the specified concentration (X% on an atomic basis) to the metal oxide (MO). The term "frit" is used to describe a mixture of inorganic compounds that usually form a glass at some temperature.

<u>Examples</u>

Described below are exemplary techniques that may be used to prepare sensor materials, and to measure signals using infrared (IR) thermographic and AC impedance techniques.

<u>IR Thermographic Samples and Measurements</u>

The change in impedance of a sensor material when exposed to a gas or gas mixture may be determined by measuring the change in temperature of the material sample by a technique such as infrared thermographic imaging.

<u>A. Array Chip Fabrication</u>

A blank array chip was made by screen printing an interdigitated electrode pattern, shown in Figure 2, onto an alumina substrate (obtained from Coors Tek, 96% alumina, 1" x 0.75" x 0.025"). A semi-automatic screen printer (ETP Electro-dial, Series L-400) was used. The electrode paste is available from DuPont *i*Technologies, product #5715. The electrode screen that was used (obtained from Microcircuit Engineering Corporation) had an emulsion thickness of 0.5 mil. After screen printing, the parts were dried in a convection oven at 120°C for 10 minutes and then fired. Firing was done